

## **Appendix B**

### **Description of Metrics Used to Quantify Visibility Effects**



### Light Extinction Coefficient

Aerosol data are used to calculate the atmospheric light extinction coefficient from experimentally determined extinction efficiencies of important aerosol species. The equation used by the IMPROVE Program to estimate reconstructed particle light extinction in  $\text{Mm}^{-1}$  is:

$$b_{\text{ext}} = b_{\text{ray}} + 3f(\text{RH})[\text{sulfates}] + 3f(\text{RH})[\text{nitrates}] + (4)[\text{organics}] + (1)[\text{soil}] + (0.6)[\text{coarse mass}] + (10)[\text{light absorbing carbon}]$$

where [ ] indicates mass concentration of the individual species (Malm et al. 2000). Some sulfates and nitrates are hygroscopic, so their scattering properties must be adjusted for the effects of relative humidity ( $f(\text{RH})$ ).

### Visual Range

Visual Range (VR) can be expressed in terms of the light extinction coefficient as:

$$\text{VR} = 3912 / (b_{\text{ext}} + b_{\text{ray}})$$

where  $b_{\text{ext}}$  is the extinction coefficient expressed in  $\text{Mm}^{-1}$ ;  $b_{\text{ray}}$  is the site specific Rayleigh values (elevation dependent) and 3912 is the constant derived from assuming 2% contrast detection threshold. The theoretical maximum VR is 391 km. Note that  $b_{\text{ext}}$  and VR are inversely related: for example, as the air becomes cleaner,  $b_{\text{ext}}$  values decrease and VR values increase. A related metric is the Standard Visual Range (SVR). This metric is indexed to Rayleigh conditions at 1800 meters elevation rather than actual Rayleigh conditions at a specific location, (i.e., set to 10  $\text{Mm}^{-1}$ ).

### Haziness

Haziness as expressed in deciview is defined as:

$$(\text{Haziness}) dv = 10 \ln(b_{\text{ext}}/10 \text{ Mm}^{-1})$$

where  $b_{\text{ext}}$  is the extinction coefficient expressed in  $\text{Mm}^{-1}$  (Pitchford and Malm 1994). A one dv change is approximately a 10% change in  $b_{\text{ext}}$ , which is a small but perceptible scenic change under many circumstances. The deciview scale is near zero (0) for a pristine atmosphere and increases as visibility is degraded.

## **References**

Malm, W.C., R. Ames, S. Copeland, D. Day, K. Gebhart, M. Pitchford, M. Scruggs, and J. Sisler. 2000. IMPROVE Report, Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report III, Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Ft. Collins, CO 80523. ISSN: 0737-5352-47.

Pitchford, M.L., and W.C. Malm. 1994. Development and Applications of a Standard Visual Index. *Atmos. Environ.* 28(5):1049-1054.